THE EFFECT OF CHEMICAL TREATMENT, FIBRE LENGTH, FIBRE CONTENT AND INJECTION MOULDING PARAMETERS TO UV IRRADIATION RESISTANCE OF OIL PALM FIBRE REINFORCED COMPOSITES

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Dedication

This Thesis is dedicated for my beloved Mother Hj. Nurlaili binti H. Buya M. Djoeri, my beloved father H. Sidi Syahriar bin Sidi Nadzir (rahimahullaalhu ta'ala), my dear wife Hj. Sri Yulita binti Sidi Nazaruddin and my precious pearls: Salma Putri Islamy, Luqmanul Hakim, Aprilia Putri Rahmah, and Muhammad Fauzan.

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ABSTRACT

There are many types of polymer used in engineering materials expose to UV irradiation, such as automotive parts (car body, bumper, dashboard etc.) which can cause material degradation. Some polymers are used in pure polymer and some of them in composite material. This study has investigated the composite material degradation. In this study, polypropylene was used as a matrix of the composite material samples, while oil palm fibre as reinforcement. The effect of the fibre length, fibre content, fibre treatment, coupling agent and injection moulding parameter to ultraviolet (UV) light resistance of this composite and also the optimum setting of them were investigated. The UV resistance was examined via the change of mechanical properties after UV exposured in the UV accelerated weathering tester. The Linear regression models were generated for tensile strength, strain at maximum stress, break stress, break strain and Charpy Impact strength based on six different UV exposure time i.e.: 0, 96, 336, 504, 1008, and 1512 hours. The significance of the regression models were tested by Analysis Of Variance (ANOVA) and verified by two expose time i.e: 168 and 672 hours. This study found that all of the mechanical properties decrease after UV irradiated. The largest property decrease was break strain of the samples, which was decrease in the range 44.54% to 79.21% after 1512 hours UV irradiated. The lowest decrease was break stress in the range 27.38 % to 63.82%. It was also found in this study that fibre content, and UV irradiation time, significantly affect all properties. Coupling agent and alkali treatment significantly affect all properties except strain at maximum stress. Whereas fibre length and injection moulding parameter only significantly affect the Impact strength of the specimens. All of the regression models are significant which are signed by the p value of each of regression models were lower than 0.05. The equation for predicting the lifetime of UV exposed of oil palm fibre reinforced composite have been generated. The lifetime UV irradiated specimen can be predicted using this equation.

ABSTRAK

Terdapat banyak jenis polimer yang digunakan dalam bahan kejuruteraan yang terdedah kepada penyinaran UV, seperti bahagian automotif (badan kereta, bumper, dashboard dll) yang boleh menyebabkan kemerosotan bahan. Beberapa polimer digunakan dalam polimer tulen dan beberapa daripadanya dalam bahan komposit. Kajian ini telah menyiasat degradasi bahan komposit. Polipropilena digunakan sebagai matriks sampel bahan komposit, manakala serat kelapa sawit sebagai tetulang. Kesan panjang gentian, kandungan serat, rawatan serat, agen gandingan dan parameter pengacuan suntikan kepada rintangan ultraviolet (UV) komposit ini dan juga tetapan optimum mereka disiasat. Rintangan UV diperiksa menerusi perubahan sifat mekanik selepas UV terdedah dalam ujian cuaca UV dipercepatkan. Model regresi Linear dihasilkan untuk kekuatan tegangan, ketegangan pada tekanan maksimum, pecah tekanan, ketegangan pecah dan kekuatan impak Charpy berdasarkan enam masa pendedahan UV yang berbeza i.e .: 0, 96, 336, 504, 1008, dan 1512 jam. Kepentingan model regresi diuji dengan Analisis Varians (ANOVA) dan disahkan oleh dua masa pendedahan i.e: 168 dan 672 jam. Kajian ini mendapati bahawa semua sifat mekanikal berkurangan selepas sinaran UV. Pengurangan terbesar adalah ketegangan pecah, yang menurun dalam lingkungan 44.54% kepada 79.21% selepas 1512 jam sinaran UV. Penurunan terendah adalah tekanan pecah dalam julat 27.38% kepada 63.82%. Ia juga didapati bahawa kandungan gentian, dan masa penyinaran UV, memberi kesan yang ketara kepada semua sifat. Ejen gandingan dan rawatan alkali banyak memberi kesan kepada semua sifat kecuali ketegangan pada tekanan maksimum. Panjang serat dan parameter pengacuan suntikan hanya memberi kesan ketara terhadap kekuatan kesan spesimen. Semua model regresi yang signifikan yang ditandatangani oleh nilai p masing-masing model regresi adalah lebih rendah daripada 0.05. Persamaan untuk meramalkan sepanjang hayat UV terdedah komposit bertetulang gentian kelapa sawit telah dihasilkan. Spesimen radiasi UV seumur hidup boleh diramalkan menggunakan persamaan ini.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS AND ABBREVIATION

ABS	-	Acrylonitrile Butadiene Styrene
a_{cN}	-	Charpy impact strength (kJ/m^2)
ANOVA	-	Analysis of Variance
ASTM	-	American Standard for Testing and Materials
α	-	Permitted property decrease limit (%)
b_0	-	Regression constant
b_1	-	Regression coefficient of x_1
b_2	-	Regression coefficient of x_2
b_3	-	Regression coefficient of x_{3A} or x_{3B}
b_4	-	Regression coefficient of x_4
b_5	-	Regression coefficient of x_5
b_N	-	The remaining width of the specimen
BFRCs	-	Banana Fibre and Redmut polymer Composites
ΔV	-	Volume change (m^3)
DF	-	Degree of Freedom
DOE	-	Design of Experiment
E	-	Young's Modulus (Pa)
E_c	-	Impact energy (J)
EFB	-	Empty Fruit Bunch
F	-	Force (N)
FTIR	-	Fourier Transform Infra-Red
G	-	Shear modulus (Pa)
γ	-	Shear strain
h	-	Impact Specimen thickness
HALS	-	Hindered Amine Light Stabilizers
HDPE	-	High Density Polyethylene
ISO	-	International Standard Organisation

J	-	Shear compliance (m^2/N)
LDPE	-	Low Density Polyethylene
MAPP	-	Maleic Anhydride Polypropylene
M_f	-	Fibre mass fraction
M_m	-	Matrix mass fraction
MS	-	Mean Squares
MSD	-	Mean Squared Deviation
NaOH	-	Sodium Hydroxide
OPB	-	Oil Palm Biomass
OPEFB	-	Oil Palm Empty Fruit Bunch
OPS	-	Oil Palm Shell
p	-	Hydrostatic pressure (Pa)
PET	-	Polyethylene Terepthalate
PC	-	Polycarbonate
PMC	-	Polymer Matrix Composite
PP	-	Polypropylene
PPE	-	Polypropylene-Ethylene
PPgMA	-	Polypropylene Grafted Maleic Anhydride
PPO	-	Polypropylene oxide
S	-	Tensile compliance (m^2/N)
SAE	-	Society of Automotive Engineers
SEM	-	Scanning Electron Microscopy
SS	-	total Sums of Squares
Tg	-	Glass transition temperature
TGA	-	Thermogravimetric Analysis
Tm	-	Melting temperature
τ	-	Shear stress (Pa)
UV	-	Ultraviolet
V_0	-	Initial volume
v	-	Poisson ratio
V_f	-	Fibre volume fraction
V_m	-	Matrix volume fraction
x_1	-	Fibre length (mm)
x_2	-	Fibre content (%)

x_{3A}	-	Coupling agent (PPgMA) concentration (%)
x_{3B}	-	Alkali (NaOH) concentration (%)
x_4	-	Injection moulding temperature (^oC)
x_5	-	UV irradiation time length (hours)
XRD	-	X-Ray Diffraction
y_1	-	Tensile strength with coupling agent (MPa)
y_2	-	Tensile strength with alkali treatment (MPa)
y_3	-	Strain at maximum stress with coupling agent (%)
y_4	-	Strain at maximum stress with alkali treatment (%)
y_5	-	Break stress with coupling agent (MPa)
y_6	-	Break stress with alkali treatment (MPa)
y_7	-	Break strain with coupling agent (%)
y_8	-	Break strain with alkali treatment (%)
y_9	-	Impact strength with coupling agent (kJ/m^2)
y_{10}	-	Impact strength with alkali treatment (kJ/m^2)
wPP	-	Waste Polypropylene

CHAPTER 1

INTRODUCTION

1.1 Research background

The development of technology and increase in population has impacted the environment. The high population increases the need for various products which may not be environmentally friendly. Continuous efforts should be made in order to manufacture the environmentally friendly products. The development of technology will increase the types of waste resulted from various products. Therefore, good waste handling is important. By separating and classifying the waste, some of the waste can be reused or recycled.

On the other hand, the use of wood materials for human purposes has proven to contribute towards deforestation. Without rigorous effort, this process of deforestation will continue. As time goes by, the forest will become bare, thus impacting the environment. The replacement of wood materials with plastic materials has a major impact on reducing forest destruction. The efforts to replace the use of wood with plastic can indirectly conserve the forest.

Wood material commonly used for household purposes such as tables, chairs, door panels, sills, and cabinets have been slowly replaced by plastic. The usage of wood material in transportation such as boats, ships, ship interiors, car interiors, has slowly moved to plastic materials (Gay, 2015), all of which help prevent forest destruction.

The plastic material can be pure plastic, a mix of different plastics, or composite materials where the plastic is mixed with other materials in order to obtain superior properties. Additional material used to reinforce the composite material can be derived from synthetic materials or natural materials, such as natural fibre. Oil palm fibre is one of the readily available natural fibres that can be used as reinforce composite materials in Indonesia and Malaysia. Recently, the availability of this fibre increased dramatically due to the increase of palm oil production.

The palm oil production in Indonesia and Malaysia are increase yearly. The increase in palm oil production for these two countries from year 2000 to 2017 are shown in Table 1.1.

Table 1.1: The increase of Palm oil Production in Indonesia and Malaysia (Murphy, 2014) (Mundi, 2018)

	Oil Production (million tonnes)	
Year	**Indonesia**	**Malaysia**
2000	8.3	11.9
2001	9.2	11.9
2002	10.3	13.2
2003	12	13.4
2004	13.6	15.2
2005*	15.6	15.5
2006	16.6	15.3
2007	18	17.6
2008	20.5	17.3
2009	22.0	17.8
2010	23.6	18.2
2011	26.2	18.2
2012	28.5	19.3
2013	30.5	20.2
2014	33.0	19.9
2015	32.0	17.7
2016	36.0	18.9
2017	38.5	20.0

Note:*The Year Indonesia became the largest producer in the world.

From Table 1.1, it can be seen that the palm oil production in Indonesia increased dramatically from 8.3 million tonnes in 2000, to 38.5 million tons in 2017. The palm oil production in Indonesia increased more than 250% in 18 years. The amount of palm oil produced in Malaysia increased from 11.9 million tonnes in the year 2000 to 20.0 million tonnes in the year 2017. Malaysia's palm oil production increased more than 60% in 18 years. As shown in Table 1.2 this increase in palm oil

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